Drivers for Companies' Entry into Standardization

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Abstract

This paper aims to identify the drivers for firms' decision to join open standards-setting organizations (SSOs). In particular, the influence of several firm characteristics such as firm size, R&D-intensity, patenting-activity, innovation-activity and sector-affiliation on the propensity to enter the German institute for Standardization (DIN e.V.) is explored. For this purpose, data of the Community Innovation Survey (CIS) 2011 for Germany is merged with the information of company's participation at the German Institute for Standardization (DIN) between 2010 and 2013. Therefore, for the first time it is possible to identify the moment when firms enter a formal SSO and, hence, eliminate the problem of simultaneity. For the multivariate estimations, a survival analysis approach is chosen, where the entrance of firms in standardization can be regarded as events taking place within the observed time period. Results show that the likelihood to enter the SSO rises with firm size. Also, companies that introduce new products or services into the market are significantly more likely to join formal standardization in the following years while R&D-intensity on its own does not have a significant positive influence. Finally, the protection of innovations by patents enhances the likelihood to enter SSOs, too. These results indicate that SSOs enable the diffusion of innovative products or services, that very small firms refrain from entering SSOs and that patenting seems to be important as protection instrument against potential knowledge spillovers.

1. Introduction

The increasing complexity of technologies and products driven by a fragmentation of intellectual property rights and a further differentiation of value chains increases the importance of platforms. On the one hand, proprietary platforms have already been analysed more than two decades ago (Kim, Kogut 1996). On the other hand, open platforms have gained attention. Especially standardization activities at formal standard setting organizations (SSOs) have been studied by several researchers. The strategic engagement of firms in SSOs (Blind and Mangelsdorf 2016) has been a topic of rising interest to the community of researchers on standardization as well as innovation over the last years. In addition, the inclusion of patents into standards is not only relevant for the buyers of consumer electronics, like smart phones, because they increase prices significantly. Standard-essential patents have been identified as an approach both to analyse the selection of technologies by SSOs to be integrated into standards and its impact on the further development of their value (Rysman and Simcoe 2008). However, the welfare implications from a theoretical perspective are much more difficult to determine (Lerner and Tirole 2015), whereas the profit maximizing strategies of forum shopping by technology owners is more straight forward (Lerner and Tirole 2006).

The previous empirical studies focus on patents (Rysman and Simcoe 2008) or scientific publications (Furman and Stern 2011) as unit of analysis. The firm perspective has been taken in the analysis of companies joining other forms of platforms, like software certification by a platform owner (Huang et al. 2013). In addition, Leiponen (2008) and Bar and Leiponen (2014) investigate companies' contributions to activities within SSOs.

There have been published some quantitative papers (Blind & Mangelsdorf, 2013; Riillo, 2013; Blind, 2006; Blind & Thumm, 2004; Wakke et al. 2015) exploring the characteristics of firms that participate in SSOs. Thereby, two limitations of previous studies are addressed: First, the limited empirical work mentioned above is either only representative for a specific sector (e.g. Wakke et al. 2015 for the service sector or Blind & Mangelsdorf (2013) for the electrical engineering and machinery industry) or rely on limited samples for the analyzed population (Blind, 2006; Blind & Thumm, 2004). Second, and even more important, all existing papers explore correlations between firm characteristics and standardization engagement using cross-sectional data and may therefore be subject to serious endogeneity problems due to simultaneity. For example, the relationship between innovations and standards is in theory assumed to be reciprocal (Allen & Sriram, 2000). Innovative companies are supposed to be more likely to participate in standardization committees since "the standardization process is a continuation of the development phase of internal R&D" (Blind, 2006). Conversely, engagement in standardization is supposed to help converting companies' R&D-results into successful innovations. Thus, it is not clear if innovative firms are more often active in SSOs or if the participation in SSOs helps firms to innovate successfully. Since both directions of causality are reasonable, it is not possible to identify the isolated effects by solely observing one point in time. However, all existing studies rely only on cross-sectional data and are not capable of identifying the driving factors for firms' decision to enter standardization.

Only Axelrod et al. (1995) elaborate their theory to form alliances by joining SSOs based on analyzing the choices of nine computer companies in a qualitative manner. Our study aims to expand the analysis of entry decisions by applying a rigorous quantitative approach not limited to a specific sector or special types of companies. Considering this development, this paper aims to reveal the drivers for a firm's decision to join committees at the main formal standard-setting organization (SSO) for Germany, the German Institute for Standardization (German: Deutsches Institut für Normung, DIN e.V.)[1].

Consequently, this paper aims to contribute to the research on the drivers for entering standardization, solving the problem of simultaneity by deploying different points in time. Using survival analysis (also known as time-to-event analysis), the effect of firm size, R&D-intensity, innovation-activity, patent-activity and sector-affiliation on the propensity to enter formal standardization organizations in the following years is identified. These variables are chosen since prior scientific work shows significant correlations between these variables and the participation in SSOs. Therefore, we can rely on data of the Community Innovation Survey for Germany ("Mannheimer Innovationspanel") 2011 which contains information about the firm characteristics for the years 2008-2010. This data is enriched with information about the participation of firms at the German Institute for Standardization (DIN) in 2010 as well as the entry of firms between 2011 and 2013. Using different points in time for observing firm characteristics (2008-2010) and the time of entry at the DIN (2011-2013) respectively, it is assured that firms' characteristics are observed before its entry at DIN. Thus, it is possible to rule out endogeneity due to simultaneity between the explaining variables and the dependent variable, since the entry at DIN cannot has an influence on the observed firm characteristics.

The remainder of the paper is structured as follows: First, the literature on the most important drivers for standardization engagement is outlined and some hypotheses are derived. Second, the sample is introduced and the empirical methodology is explained. Afterwards, results of the survival analysis are presented. Finally, the results are discussed and some implications are presented.

2. Theoretical Considerations

As outlined in the introduction of this paper, standardization has become an increasingly strategic tool for companies over the last decades. Regarding the strategic involvement of companies in standardization processes, a path-breaking work is the paper "Choosing How to Compete: Strategies and Tactics in Standardization" written by Besen and Farrell in 1994. The authors emphasize the growing importance of the subject by stating that "standard-setting has been transformed from an internal matter for individual firms to a subject of cooperation and competition among individual players." (Besen & Farell, 1994, pp.117) Moreover, they highlight that "…a firm that controls a technology that becomes establishes as a standard can have an extremely profitable market position,…" (Besen & Farell, 1994, pp.119). This is especially true for so-called "standard-wars"[2] which can lead to a single dominating de-facto-standard. However, as an alternative to competing between standards, companies can agree on a common standard which might be developed in formal SSOs. The standardization process in formal SSOs is (in contrast to most consortia) open to all interested parties, thus no one can be excluded. There are several reasons for firms to join formal standardization in SSOs and, thereby, to help developing standards. In particular, companies contribute to the standardization process even if formal standards are seen as public goods in the literature (see e.g. Kindleberger, 1983; Swann, 2000 or Swann, 2010) for which it is not possible to appropriate the outcome of the standardization process to the firm exclusively. However, the involvement in the development process facilitates the implementation of the standard and creates a competitive advantage compared to firms not active in the standardization process (Wakke et al. 2016). Likewise, companies can influence

[1] This paper focuses exclusively on the participation in open SSOs and does not cover participation in closed consortia since there are probably other factors influencing the likelihood to enter.

[2] Examples for standard wars are VHS vs. BETAMAX, Nintendo vs. Sony and Microsoft vs. Apple.

the upcoming standards in the standardization process and hence raise cost for their rivals (Salop & Scheffman, 1983), fight for the best position to diffuse their technologies (Blind & Gauch, 2009; Iversen et al., 2004), and, thereby, raise their own market shares (Leiponen, 2008; Wakke et al., 2015). Moreover, regarding the relationship of standardization and standards, Blind and Rauber (2013) disclosed for a sample of R&D-active and innovative firms that there are significant links between the reasons to participate in the standardization process and the motives to implement standards, e.g. to secure a specific level of quality, within the firm. This is another indication that the participation in SSOs is not arbitrary, but strategically and – as we will explain later – contingent on firm characteristics. The main characteristics according to the literature and their possible influence on the decision to enter standardization are discussed in the following. Furthermore, some hypotheses are derived which build the basis for the empirical part of this paper.

Firm size and standardization

Blind and Thumm (2004) are the first ones that come to the conclusion that "the most decisive factor for participation in the standardization process is company size". This positive relationship is confirmed by Blind (2006), Blind et al (2011) as well as Blind and Mangelsdorf (2013) and Wakke et al. (2015) for service companies. There are several possible explanations for the positive correlation between firm size and participation in formal standardization. Since the engagement in standardization is costly and time consuming, larger firms might be more willing to join SSOs than smaller ones due to greater resources they can spend on different business-related tasks, standardization being one among them (Blind, 2006). On the other hand, firms that participate in standardization committees might grow due to the positive effects of the standardization process such as knowledge spillovers or the possibility to influence a standard which might lead to facilitated market access. This endogeneity problem might bias the results of the papers using cross-section analysis. It is solved in this paper since the influence of firm size on the likelihood to enter standardization can be investigated separately by deploying different points in time. Thus, the explanation that larger firms have more resources and are therefore more likely to enter a SSO is central in the line of argument here. However, the largest firms are supposed to be already active at the DIN before 2011 since the engagement in formal standardization is a long term strategy. Moreover, all large firms that are not already active in standardization might be in such a strong market position that they do not need the support of formal standards (see e.g. Blind and Thumm, 2004), because they might have already promoted their technologies to dominant designs (e.g. Suarez 2004) in their industries. Based on the size characteristics of companies already active in SSOs, an inverted U-shaped-relationship between firm size and the propensity to enter formal SSOs is also expected which leads to the first hypothesis:

H1: The relationship between firm size and the likelihood to enter formal standardization is curvilinear (inverse U-shaped), with the highest likelihood occurring at an intermediate firm size.

R&D-intensity and standardization

In the literature (e.g. Blind, 2006), standardization is perceived as the next phase of internal R&D. Blind & Gauch (2009) even have developed an integrative approach of research and standardization and exemplary confirmed for nanotechnology. Moreover, R&D-intensive companies have a higher absorptive capacity defined as "a firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990), indicating that the ability to profit from knowledge spillovers generated in standardization processes is more distinct for these firms (Blind & Mangelsdorf, 2013). Since knowledge sourcing is one of the main reasons for joining SSOs, R&D-intensive companies might be more likely to enter SSOs. However, knowledge spillovers can detain very R&D-intensive firms from entering standardization since possible spillovers are more a threat than an opportunity to these companies (see Blind & Mangelsdorf, 2013). Consequently, the study by Blind (2006) reveals an inverse U-shaped relationship between R&D-intensity and the likelihood of companies to be active in SSOs, i.e. the relationship is positive up to an R&D-intensity of 4%. Therefore, we leverage these insights to the initial company characteristics before entering SSOs and derive the following second hypothesis:

H2: The relationship between R&D-intensity and the likelihood to enter formal standardization is curvilinear (inverse U-shaped), with the highest likelihood occurring at an intermediate level of R&D-intensity.

Innovation activities and standardization

The hypothesis concerning successful innovations is strongly connected to the hypothesis about R&D-intensity. Expenditures for R&D can be regarded as input of the innovation process, while product or services new to the market (”successful innovations”) represent the output of R&D (Greenhalgh &Rogers, 2010). However, companies can be successful in innovation without spending resources for R&D (source). Therefore, we distinguish between R&D activities and innovation success as drivers for companies entering SSOs.

Regarding the relationship between successful innovations and standardization, Tassey (2000) states that “Standards affect the R&D, production, and market penetration stages of economic activity and therefore have a significant collective effect on innovation, productivity, and market structure.” Conversely, this means that firms have to decide strategically about entering SSOs at all and their efforts in shaping standards, especially if they are very innovative and want to penetrate the market with new products. Moreover, Hussinger and Schwiebacher (2015) find that “disclosure of standard-relevant IP ownership is positively related with company valuation if associated patent rights are referred to explicitly”, which is recently confirmed by Pohlmann et al. (2105). Therefore, they suggest, “that product market advantages from standardized technology outweigh the loss of exclusivity from contributed IPR” (Hussinger & Schwiebacher, 2015). Following this thought, companies that conduct successful product or service innovation might have higher incentives to join formal SSOs and to shape the relevant standards in order to gain product market advantages rather than enforcing their IP exclusively. The next hypothesis is hence formulated as follows:

H3: The likelihood to enter formal standardization processes is higher for firms that successfully introduce product or service innovations to the market.

Patent-activities and standardization

As stated above, firms may abstain from enforcing exclusive rights such as patents in order to create standards which facilitate access to the market. Also in economic theory, patents as a proprietary instrument and standards as public or club goods (Kindleberger 1983) have been seen as contradicting instruments for a long time. While patents are an instrument to appropriate the revenues of R&D-expenditures, formal standards (and hence the yielded knowhow of a company) are open to all firms. Empirically, Blind and Thumm (2004) explore the relationship between patenting and standardization strategies, i.e. they measure the influence of firms’ patent portfolios and other firm characteristics on the likelihood to participate in formal standardization on national, European or international level. They discover that a higher patent intensity lowers the likelihood to participate in standardization. This indicates that very patent-intensive firms are reluctant to join standardization. However, they do not find a significant effect of the mere patent activity. Moreover, seeing standardization as some kind of firm collaboration, Olander et al. (2014) state: “Firms with IPR protection may feel more inclined to collaborate because of the smaller perceived risk.” (Olander et al, 2014, pp.208) Thus, a high degree of patent protection might be necessary in order to protect against potential knowledge spillover. Another important reason for patenting companies to join standardization is to introduce standard essential patents in the standard so as to gain licensing revenues according to FRAND[3] terms from all standards user (Lemley, 2002) which may outweigh the loss of exclusivity (Hussinger & Schwiebacher, 2013). This is especially true for the ICT sectors (Rysman & Simcoe, 2008; Bekkers et al., 2002). Consequently, mere patent activity is expected to raise the likelihood to join formal standardization.

H4: The likelihood to enter formal standardization processes is higher for patenting firms.

3. Data and Methodology

Sample description

In order to obtain a dataset which allows testing the developed hypotheses, data from the Mannheim Innovation Panel (MIP) 2011 is matched with information about the standardization activities of German companies between 2010 and 2013 at the German Institute for Standardization (DIN e.V.). The MIP is conducted on an annual basis by the Centre for European Economic Research in Mannheim (ZEW) since 1995, representing the Community Innovation Survey (CIS) for Germany. Although the MIP only includes companies with five or more employees, it is considered as representative for the corporate landscape in Germany[4]. As several firm characteristics are expected to influence the decision to join formal standardization in the future (which is the core question of this analysis), the data about firm characteristics has to be observed prior to the information about the standardization engagement in order to utilize survival analyses. Therefore, the survey from 2011 of the Mannheimer Innovations Panel is used since its information refers to the period from 2008 to 2010. It contains information about the successful introduction of new products or services into the market, patenting activities as well as expenditures on research and development. Furthermore, some additional information about companies’ background characteristics such as turnover and sector affiliation[5] are available. Finally, a dataset of 4,071 observations is obtained from which 2% (78 observations) started standardization activities at the DIN between 2011 and 2013 and about 6% (238 observations) have already been active in 2010 (“established standardizers”). Since entries before 2011 and after 2013, respectively, cannot be observed, the sample is left- and right censored. The descriptive statistics for all relevant variables are available in table 1.

[3] FRAND is short for “fair, reasonable and non-discriminatory” licensing terms.
[4] For further information about the MIP, see http://www.zew.de/en/projekte/374.
[5] Since the number of observations for the dependent variable is quite small, it is not possible to control for differences between single sectors. Thus, it is controlled for differences between the higher and lower technology sector within the groups of service and manufacturing companies based on the OECD Manual. The according sectors are higher- technology manufacturing industries (HTMI; consisting of high and medium-high-technology industries), lower-technology manufacturing industries (LTMI; consisting of low and medium-low-technology industries)as well as knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS) For further information see http://www.oecd.org/science/inno/48350231.pdf and http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/Annexes/htec_esms_an3.pdf.

Table 1: Descriptive statistics: means and shares of the sample (standard deviation).

Variables	Total (N=4,071)	Non-standardizers (N=3,755)	Entering firms (N=78)	Established standardizers (N=238)
Firm size (average turnover in millions €)	50.94 (490.80)	38.23 (448.32)	228.35 (1057.93)	193.41 (745.79)
Average R&D-intensity (R&D-expenditures/turnover)	0.03 (0.08)	0.02 (0.08)	0.06 (0.13)	0.05 (0.13)
Share of patenting firms (Patent application 2008-10)	0.31 (0.46)	0.28 (0.45)	0.68 (0.46)	0.75 (0.43)
Share of innovative firms (Market introduction 2008-10)	0.47 (0.50)	0.44 (0.49)	0.77 (0.42)	0.79 (0.41)
Share of firms from lower-technology manufacturing industries (LTMI)	0.34 (0.47)	0.34 (0.47)	0.21 (0.41)	0.34 (0.47)
Share of firms from higher-technology manufacturing industries (HTMI)	0.19 (0.39)	0.17 (0.37)	0.40 (0.49)	0.45 (0.50)
Share of firms from knowledge-intensive services (KIS)	0.36 (0.48)	0.38 (0.48)	0.35 (0.48)	0.18 (0.38)
Share of firms from less knowledge-intensive services (LKIS)	0.11 (0.31)	0.12 (0.32)	0.05 (0.22)	0.04 (0.20)

It becomes obvious that firms that have been active at the DIN before 2011 (“Established standardizers”) and firms that entered between 2011 and 2013 (“Entering firms”) are quite similar, while both groups differ very much from firms that do not enter the DIN in the observed time period (“Non-standardizers”). This is true for the variables firm size (based on average turnover), R&D-intensity (measured as ratio of expenditure for R&D) and companies’ turnover as well as innovation- and patenting activities. However, having a look at the sectors distribution, it falls into place that there are also some differences between entering firms and established standardizers (see table 1). Whereas about 35% of the companies that entered the DIN between 2011 and 2013 stem from knowledge-intensive services (KIS), this is only the case for about 18% of the companies that have been active at the DIN at the beginning of the observation period. However, while 34% of the established standardizers belong to the lower-technology manufacturing industries (LTMI), this is only true for 21% of the entering companies. Regarding the higher-technology manufacturing industries (HTMI) and the less Knowledge-intensive services (LKIS) respectively, there are only small differences between established standardizers and entering companies. Altogether, it can be stated that firms that enter SSOs as well as established standardizers are larger, more R&D-intensive, more likely to be patent-active and innovative than companies that did not start standardization activities in the observed period at all. Moreover, it seems like standardization is getting more important in knowledge intensive service industries since they represent a high share of the entering companies. The opposite seems to be true for companies of LTMI. Multivariate estimations are conducted in the following in order to carve out which of these firm characteristics have significant influences on the likelihood of companies to enter SSOs.

Estimation method and important concepts

The main aim of this paper is to identify the relevant firm characteristics that influence the firm decision to enter a SSO. Since it is possible to observe the firm characteristics in 2010 and the entries of firms in the years 2011, 2012 and 2013, survival analysis (also called time-to-event-analysis) is an adequate estimation method. In survival analysis, the dependent variable is determined by the duration of an observation in the sample until the event happens (failure) or it is not observed anymore. Thus, it is a combination of the length of the observed time without event or censoring and the event variable which is 1 if the event happens and 0 otherwise. In the context of this paper, observations are tracked until they enter standardization or are not observable anymore.

The two main concepts of this approach are the survival rate and the hazard rate. The survival rate *S(t)* is defined as the probability that the duration of an observation in the sample is at least *t* and thus is equal to 1- *F(t)*, which represents the converse probability that the duration will be less than *t*:

$$F(t) = Prob(T \leq t) = \int_0^t f(s)ds$$

$$S(t) = 1 - F(t) = Prob(T \geq t)$$

Thus, it indicates how long it takes until an event happens (i.e. how long does it take until a firm enters standardization). The hazard rate captures the likelihood for a company to fail (i.e. to enter standardization), i.e. it is defined as the probability that the event will happen given that the company is still alive[6]:

$$h(t) = \frac{f(t)}{S(t)}$$

The cumulative hazard function is the accumulation of all hazard rates over time, i.e. the probability that the event has occurred at a certain point in time. The survivor function is usually pictured as Kaplan-Meier-survival curve (Kaplan & Meier, 1958) and depicts the share of observations that have not experienced the event (i.e. entered standardization) over time. Since there are only four points in time and a constant hazard ratio in the Cox proportional model (which is applied in this paper) is assumed, graphical presentations of these non-parametric estimations are not very meaningful and, thus, not presented here. Rather, the distribution of the events over time and the survival function are shown in table 2.

Table 2: Distribution of the survivor function.

Year (t)	Observations at beginning of the period without event	Events in year t	Net Lost	Survivor Function	Std. Error	[95% confidence intervall.]	
0	4,071	238	238	-	-	-	-
1	3,833	22	0	0.9943	0.0012	0.9913	0.9962
2	3,811	37	0	0.9846	0.0020	0.9802	0.9881
3	3,774	19	3755	0.9797	0.0023	0.9747	0.9837

[6] Obviously, the hazard rate can change over time, i.e. it can rise and fall. In the case of the "risk" to enter standardization, the hazard rate might change according to firm age. However, since the age of a firm is not known and therefore the point in time the characteristics are observed is arbitrary, the Cox proportional model is applied and a constant hazard rate is assumed in order to facilitate the analysis and the interpretation of the results.

The 238 observations which are failures from the beginning represent firms that are already active in SSOs in period 0. Consequently, it is not possible to include them into the further analysis. Furthermore, between 19 and 37 firms enter standardization after period 0. Since it is not possible to observe them after 2013, all observations leave the sample after three periods and the net loss is 3755.

As stated above, the group of the 238 established standardizers cannot be included in the survival estimation since their entry is left censored. However, the characteristics of already standardizing companies within a sector might influence the likelihood of other firms to join the DIN. For example, companies might join standardization committees because there are already some very large companies active in standardization in this field (see Axelrod, 1995). Additionally, companies that exhibit lower R&D-intensities compared to the average standardizing company in their sector might be more likely to enter standardization due to potential knowledge spillovers of the R&D-intensive established standardizers.

Thus, two additional estimations as robustness checks are conducted since it is not possible to include the group of established standardizers in the upcoming estimations due to the features of survival analysis. First, the own R&D-intensity divided by the average R&D-intensity of the established standardizing companies in the sector (variable called “proportion R&D”) as well as the own firm size divided by the average firm size of the established standardizing companies in the sector (variable called proportion size) are included in the estimations separately. Significant negative influences would direct to the conclusion that companies with lower R&D-intensities respectively firm size compared to the average standardizing company in their sector are more likely to enter standardization and, accordingly, that the group of established standardizers has an significant impact on the decision to join the DIN. As a second robustness check, it is simulated that all left-censored observations (i.e. the established standardizers) enter in the first observation period and the following entries are moved back by one period. Thereby, the influence of the characteristics of the established standardizers on the outcome variable is included in the estimation. Significant changes in the sign and size of coefficients would indicate that there are substantial differences between new entering companies and established standardizers.

For the multivariate part, the Cox proportional model (Cox, 1972) is applied where the hazard ratios or coefficients can be reported. The hazard ratios are connected to the hazard rate and can be interpreted in the following way: A hazard ratio of e.g. 1.5 means that a one unit increase of the explaining variable equals a rise of the hazard rate by 50%. On the contrary, a hazard ratio of 0.7 means that a one unit increase of the explaining variable leads to a decline in the hazard rate of 30%. Thus, a hazard ratio of greater than one means that the event is more likely to happen and therefore a lower duration in the sample is expected while a ratio less than one indicates that the event is less likely to happen and the duration is higher. Since the influence of the variables on the likelihood to enter standardization is the main interest here, the hazard ratios will be reported in the result table due to their meaningful interpretation.

4. Results

In the following Cox proportional estimations, all variables of table 1 as well as quadratic terms for firm size and R&D-intensity are included in order to identify the driving forces for the decision of a firm to start participating at the DIN and the results are depicted in estimation (1). Moreover, estimations (2) and (3) present the results of the robustness checks mentioned in chapter 3. All estimation results are displayed in table 3.

Table 3: Results of the Cox proportional estimation with different sets of explaining variables.

Variables	(1) hazard ratio	(2) hazard ratio	(3) hazard ratio
Turnover (in millions €)	1.001**		1.001***
	(0.0004)		(0.0002)
Turnover square (in millions €)	0.999*		0.999***
	(5.39e-08)		(2.65e-08)
R&D-intensity	2.204	3.693	1.977
	(5.052)	(11.75)	(2.308)
R&D-intensity (square)	0.852	0.764	1.445
	(2.742)	(2.569)	(2.200)
Patenting	3.493***	3.486***	3.798***
	(0.929)	(0.922)	(0.529)
Innovation	2.157***	2.274***	2.025***
	(0.634)	(0.665)	(0.303)
Proportion size		1.021	
		(0.0155)	
Proportion R&D		0.950	
		(0.124)	
HTMI	2.276***	2.308***	1.492***
	(0.723)	(0.739)	(0.208)
KIS	1.337	1.368	0.596***
	(0.437)	(0.471)	(0.0982)
LKIS	0.918	0.946	0.560**
	(0.517)	(0.531)	(0.161)
Likelihood -Ratio	77.33	84.00	362.47
Prob > chi2	0.00	0.00	0.00
Observations	3,833	3,833	4,071

Hazard ratios with standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
LTMI is the reference category

First, it has to be mentioned that all estimations fit the Cox proportional model quite well according to the Likelihood-Ratio-Test and that there seems to be no multicollinearity issues since the variance inflation factors (VIF) of all variables are low.[7]

Estimation (1) shows the results of the main regression. At first glance, the results show that there is a non-linear relationship between firm size and the likelihood to join standardization committees, since the influence of the linear firm-size term is significantly positive (i.e. Hazard Ratio greater than one), while its square term is significantly negative (i.e. Hazard Ratio less than one).[8] Moreover, the significant positive coefficient of the patenting variable is very interesting. Conversely, R&D-intensity per se does not enhance the likelihood to enter standardization, but then again the introduction of successful innovations

[7] According to Myers (1990), multicollinearity is expected if the VIF of an explaining variable is greater than 10. This is not the case in all three estimations. The VIFs for the explanatory variables of all estimations are presented in table A1 in the appendix of the paper.
[8] An estimation without the square term for firm-size was conducted. However, the coefficient was insignificant. Thus, the squared term was included.

to the market does.[9] Apparently, especially firms with successful R&D-activities which lead to market-ready innovations are starting standardization activities at the DIN. Regarding the differences between sectors, it becomes obvious that companies from higher-technology manufacturing industries are more likely to enter standardization compared to companies from lower-technology manufacturing industries, which is the reference category in the estimations. Moreover, changing the reference category reveals that companies from higher-technology manufacturing industries are also more likely to enter SSOs compared to knowledge-intensive service industries (KIS) as well as less knowledge-intensive service industries (LKIS). Finally, there are no significant differences between companies from lower-technology manufacturing industries, knowledge-intensive service industries (KIS) or knowledge-intensive service industries (LKIS)[10].

The variables controlling for possible influences of the group of established standardizing companies in estimation (2) have no significant effect on the likelihood to start participation at the DIN for the other firms[11] and the influences of the explaining variables remain significant. Including the established standardizers in estimation (3) does also not change the results, except for the sector dummies. Firms from the service sector are significantly less likely to be active in standardization compared to firms from the LTMI, since there are many companies from low-technology manufacturing industries among the established standardizers. Altogether, the results of estimation (1) can be regarded as robust.

5. Summary, Limitations and further Research

The main aim of this paper is to identify the most important firm characteristics that influence the decision to join standardization. In contrast to previous research approaches which rely on cross-sectional analyses, different points in time for the explaining and the dependent variables are used. Therefore, possible endogeneity problems, in particular between innovation and standardization or firm size and standardization, can be ruled out which is one of the main contributions of this paper. An appropriate tool to analyze this kind of data is the Cox Proportional Model, a semi-parametric survival analysis estimation method. The results of this analysis reveal that a higher R&D-intensity per se does not lead to an enhanced probability to enter standardization. However, companies that have successfully developed innovations are more likely to join SSOs. Moreover, patent protection seems to be an important issue when it comes to the decision to enter a SSO since knowledge spillovers are seen as main issues of standardization (Blind & Mangelsdorf, 2013). Finally, it can be stated that with increasing firm size also the benefits from participating in standardization processes rise.

From a managerial perspective, it seems to be beneficial for firms with successful innovations to enter standardization. Thus, firms should consider the option of standardizing a new product or service when they think about the opportunities for the marketing of innovations. However, firms need to be prepared against possible knowledge spill-overs by protection their intangible assets since there is a lot of knowledge exchange in the standardization process.

Also, there are some policy implications. Despite some efforts of the German government to support small firms, this group of companies seems still to abstain from entering standardization. This is probably the case due to a lack of resources and capacities of these firms which are needed in order to participate in standardization (see Blind & Rauber, 2012). Also, small firms might not be aware of all opportunities that the participation in

[9] Also, an estimation without the square term for R&D-intensity was conducted. Like in the estimation including the squared term, the coefficient was insignificant. Thus, a significant influence of R&D-intensity can be ruled out.
[10] Results with changed base categories are not shown in the tables due to shortage of space. Results are available upon request.
[11] Firm size was excluded in this estimation due to multicollinearity issues with the variable prop_size_normer.

standardization can offer them. Thus, politics have to think about new ways to help these firms to overcome possible obstacles so that their knowhow can be integrated in the standardization process and hence in new standards.

For all that interesting results, some limitations of this paper have to be mentioned. First, the results are only representing the German corporate landscape. Furthermore, the role of the competitive environment are not included in the analysis and a more differentiated sector classification would be appreciated. Therefore, a larger number of entering companies would be necessary which is desirable anyway in order to verify the results. Likewise, a real panel analyses would be preferable in order to account for changes of the firm characteristics in the observation period. In this context, it has to be alluded that it is not possible to rule out the influence of possible unobserved shocks after 2010 on the observed entries at the DIN between 2011 and 2013. Also, including the established standardizers in the estimations is not possible using survival analysis. Even though these observations were included in some robustness checks, further research should address this issue in more detail. A closer look at the relationship between patenting, market introduction of innovations and standardization engagement is also a potential task for further research since the analysis revealed the significant importance of these variables for companies that enter standardization.

Despite these limitations, this paper constitutes as a first approach regarding the topic of drivers for entering standardization and contributes in particular to research by differentiating between firms that enter standardization and established standardizers.

References

Allen, R. and Sriram, R. (2000). The role of standards in innovation. *Technological Forecasting and Social Change* 64, 171-181.

Axelrod, R., Mitchell, W., Thomas, R.E., Bennett, D.S., Bruderer, E. (1995). Coalition Formation in Standard-Setting Alliances. *Management Science* 41 (9), 1493–1508.

Bar, T. and Leiponen, A. (2014). Committee Composition and Networking in Standard Setting: The Case of Wireless Telecommunications. *Journal of Economics & Management Strategy* 23 (1), 1-23.

Baron, J. and Pohlmann, T. (2013). Who Cooperates in Standards Consortia – Rivals or Complementors? *Journal of Competition Law & Economics* 9 (4), 905-929

Bekkers, R., Verspagen, B., Smits, J. (2002). Intellectual property rights and standardization: the case of GSM. *Telecommunications Policy* 26 (3-4), 171–188.

Bekkers, R., Bongard, R., Nuvolari, A. (2011). An empirical study on the determinants of essential patent claims in compatibility standards. *Research Policy* 40 (7), 1001-1015.
Besen, S.M. and Farrell, J. (1994). Choosing How to Compete: Strategies and Tactics in Standardization. *Journal of Economic Perspectives* 8 (2), 117–131.

Blind, K. (2006). Explanatory factors for participation in formal standardisation processes: Empirical evidence at firm level. *Economics of Innovation and New Technology* 15 (2), 157–170.

Blind, K. and Gauch, S. (2009). Research and Standardization in Nanotechnology: Evidence from Germany. *Journal of Technology Transfer* 34 (3), 320–324.

Blind, K. and Mangelsdorf, A. (2013). Alliance Formation of SMEs: Empirical Evidence From Standardization Committees. *IEEE Transactions on Engineering Management* 60 (1), 148–156.

Blind, K. and Mangelsdorf, A. (2016). Motives to Standardize: Evidence from Germany, *Technovation* 48-49, 13–24.

Blind, K. and Thumm, N. (2004). Interrelation between patenting and standardisation strategies: empirical evidence and policy implications. *Research Policy* 33 (10), 1583–1598.

Cohen, W.M. and Levinthal, D.A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* 35 (1), 128.

Cox, D. (1972). Regression models and life tables. *Journal of the Royal Statistical Society* 34 (2), 187 - 220.

Furman, J. L. and Scott Stern (2011). Climbing atop the Shoulders of Giants: The Impact of Institutions on Cumulative Research. *American Economic Review* 101, 1933–1963

Greenhalgh, C. and Rogers, M. (2010). Innovation, Intellectual Property, and Economic Growth, published by *Princeton University Press.*

Huang, K. G. and Murray, F. E. (2009). Does Patent Strategy Shape the Long-Run Supply of Public Knowledge? Evidence from Human Genetics. *Academy of Management Journal* 52 (6), 1193-1221.

Huang, P., Ceccagnoli, M., Forman, C., Wu. D. J. (2013). Appropriability Mechanisms and the Platform Partnership Decision: Evidence from Enterprise Software. *Management Science* 59 (1), 102-121

Hussinger, K. and Schwiebacher.F. (2015). The Value of Disclosing IPR to Open Standard Setting Organizations. *Industry and Innovation* Vol 22 (4), 321-344.

Iversen, E., Oversjoen E., Thue, L. (2004). Standardization, innovation and IPR. *Telektronikk* 100 (2), 65–79.

Kaplan, E. and Meier, P. (1958). Nonparametric estimation from incomplete observations. *J. Amer. Statist. Assn.* 53, 457–481.

Kim, D. J. and Kogut, B. (1996). Technological platforms and diversification. Organization Science 7(3), 283-301.

Kindleberger, C. P. (1983). Standards as Public, Collective and Private Goods. *Kyklos*, 36: 377–396.

Layne-Farrar, A. and Lerner, J. (2011). To join or not to join: Examining patent pool participation and rent sharing rules. *International Journal of Industrial Organization* 29, 294–303.

Layne-Farrar, A., Llobet, G., Padilla, J. (2014). Payments and Participation: The Incentives to Join Cooperative Standard Setting Efforts. *Journal of Economics & Management Strategy* 23 (1), 24-49.

Leiponen, A.E. (2008). Competing Through Cooperation: The Organization of Standard Setting in Wireless Telecommunications. *Management Science* 54 (11), 1904–1919.

Lemley, M.A. (2002). Intellectual Property Rights and Standard-Setting Organizations. *California Law Review* 90 (6), 1889.

Olander, H., Vanhala, M., Hurmelinna-Laukkanen, P. (2014). Reasons for choosing mechanisms to protect knowledge and innovations. *Management Decision* 52 (2), 209-229.

Pohlmann, T., Neuhäusler, P., Blind, K. (2016) Standard Essential Patents to Boost Financial Returns, forthcoming R&D Management

Ranganathan, R. and Rosenkopf, L. (2014). Do Ties Really Bind? The Effect of Knowledge and Commercialization Networks on Opposition to Standards. *Academy of Management Journal* 57 (2), 515-540.

Riillo, C. (2013). The participation in standardization activities - A firm level analysis of formal and company standards. in: *18th EURAS Annual Standardisation Conference Proceedings* "Boosting European Competitiveness" 7.

Rysman, M. and Simcoe, T. (2008). Patents and the Performance of Voluntary Standard-Setting Organizations. *Management Science* 54 (11), 1920–1934.

Salop, S.C. and Scheffman, D.T. (1983). Raising rivals' costs. *Bureau of Economics, FTC*, Washington, D.C.

Somaya, D. (2012). Patent Strategy and Management: An Integrative Review and Research Agenda. Journal of Management 38 (4), 1084-1114.

Swann, P. (2000). The Economics of Standardization. Final Report for Standards and Technical Regulations. *Directorate Department of Trade and Industry, Manchester*: University of Manchester.

Swann, P. (2010). The Economics of Standardization: An update, *Report for the UK Department of Business, Innovation and Skills (BIS)*.

Tassey, G. (2000). Standardization in technology-based markets. *Research Policy* 29 (4-5), 587–602.

Vasudeva, G., Spencer, J. W., Teegen, H. J. (2013). Bringing the Institutional Context Back In: A Cross-National Comparison of Alliance Partner Selection and Knowledge Acquisition. *Organization Science* 24 (2), 319-338.

Vasudeva, G.; Alexander, E. A.; Jones, S.L. (2015). Institutional Logics and Interorganizational Learning in Technological Arenas: Evidence from Standard-Setting Organizations in the Mobile Handset Industry. *Organization Science* 26(3), 830-846

Waguespack, D.M. and Fleming L. (2009). Scanning the Commons? Evidence on the Benefits to Startups Participating in Open Standards Development. *Management Science* 55(2), 210-223.

Wakke, P.; Blind, K.; De Vries, H. (2015): Driving factors for service providers to participate in standardization: Insights from the Netherlands, *Industry & Innovation* 22 (4), 299-320.

Wakke, P., Blind, K.; Ramel, F. (2016). The impact of participation within formal standardization on firm performance, *Journal of Productivity Analysis* 45(3), 317–330.

Appendix

Table A1
Variation inflation factors for all estimations

Estimation Variables	(1) VIF	(2) VIF	(3) VIF
Turnover (in millions €)	4.23	-	3.91
Turnover (square)	4.22	-	3.89
R&D-intensity (R&D-expenditures/turnover)	5.78	8.47	5.95
R&D-intensity (square)	5.47	5.78	5.64
Patent-activity (Application 2008-10)	1.16	1.16	1.19
Innovation-activity (Market introduction 2008-10)	1.21	1.21	1.23
Proportion size	-	1.00	-
Proportion R&D	-	2.40	-